California Energy Commission

STAFF REPORT

Energy Efficiency Comparison

California's 2016 *Building Energy Efficiency Standards* and International Energy Conservation Code - 2015

California Energy Commission

Edmund G. Brown Jr., Governor

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ABSTRACT

The federal Energy Policy Act of 1992 requires each state to certify that it has reviewed and considered adopting the national model energy standard. Every state must determine if its energy code meets or exceeds the current federal reference code and certify to the Secretary of the U.S. Department of Energy its determination. The federal reference energy code for residential buildings is the International Energy Conservation Code (IECC).

States must reevaluate the efficiency requirements of their code against those of the new federal building efficiency reference codes. This report documents the California Energy Commission's response to this federal law by comparing the energy savings effects between California's*2016 Building Energy Efficiency Standards* Title 24, Part 6, to the residential energy requirements of the 2015 International Energy Conservation Code.

This report concludes that California's *Building Energy Efficiency Standards* exceed the energy savings expected from the residential Chapter 4 of the 2015 International Energy Conservation Code. While significant improvements have been made to the energy stringency levels of the national reference energy codes, California's residential energy standards contain building measures and building performance operation impacts that are more rigorous, resulting in higher efficiency levels for new residential construction than expected to occur from efficiency requirements of the federal reference energy codes.

Keywords: California Energy Commission, *Building Energy Efficiency Standards*, International Energy Conservation Code, energy comparison

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CHAPTER 1: Introduction

States are required by federal law to adopt an energy code that is at least as energy-efficient as the federal reference model energy code. When a new national model energy code is adopted, the U.S. Department of Energy (DOE) is required to determine whether the newly adopted code is more stringent than the predecessor. Each state has two years after the publication of this determination to certify that it has reviewed the provisions of its nonresidential building code regarding energy efficiency and to report whether it is appropriate to revise those energy code requirements to meet or exceed the newly adopted reference national model energy code. The federal reference energy code for residential buildings is the *International Energy Conservation Code (IECC) – 2015*.

This staff analysis compares the estimated energy savings for residential building energy efficiency measures of the *2016 Building Energy Efficiency Standards* to the nonresidential requirements of the *IECC – 2015*.

Building Energy Efficiency Standards

The California Energy Commission adopted energy standards in 1977 and continues to revise these requirements in response to legislative mandates, changes, and improvements to building systems and designs, and to improve compliance and enforcement. Overall, the Energy Commission's revisions to the residential and nonresidential standards have resulted in significant statewide energy savings and remain a cornerstone of state policy to reduce statewide energy use and greenhouse gas emissions. The *Building Energy Efficiency Standards* are contained in Part 6 of Title 24, California Code of Regulations, and are often simply referred to as "Title 24."

The standards are separated into two parts: low-rise residential buildings of three stories or fewer, and nonresidential buildings, which include high-rise residential buildings four stories or higher and hotel/motel occupancies. This report analyzes low-rise residential buildings, while nonresidential buildings and high-rise residential buildings were discussed in the September 2016 report[1] (CEC-400-2016-017).

There are two methods of demonstrating compliance with the standards: prescriptive and performance. With either method, there are mandatory measures that must always be met listed in Sections 110.0 through 110.11 and Section 150.0. Many of the mandatory measures deal with infiltration control, indoor and outdoor lighting,

1 http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-400-2016-017

minimum equipment efficiency and minimum envelope, water system piping, and cooling system insulation levels. The minimum mandatory levels are sometimes supplemented by more stringent prescriptive or performance requirements.

With the prescriptive method of compliance, every applicable measure listed in the standards Sections 150.1 and 150.2 must be met or exceeded for the building to comply. These sections include requirements for the building envelope, space-conditioning system, domestic water heating systems, and roofing products. The prescriptive approach offers relatively little design flexibility but is easy to use.

The performance approach allows compliance through a wide variety of design strategies and provides greater flexibility than the prescriptive approach. When the performance approach is used, the energy effects of building features are analyzed to determine the overall effect of these features on the total energy use of the building through alternative calculation method compliance software approved by the Energy Commission. Measures, such as window U-factors, can be less efficient than the prescriptive requirement so long as other measures used in other areas exceed the prescriptive requirement, resulting in less overall energy use.

Reference Model Energy Codes

Building energy codes are minimum requirements affecting energy-efficient design and construction for new and renovated residential and commercial buildings. Overall, building regulations govern all aspects of the design and construction of buildings, and building energy codes set an energy efficiency baseline for the building envelope, building systems, and operating equipment. Improving these minimum requirements or broadening the scope of energy codes helps soften the environmental impact of buildings and result in additional energy and cost savings over the life cycle of a building.

Before passage of the 1992 Energy Policy Act, the federal government applied little pressure on states to improve the efficiency of buildings, although equipment improvements were federally mandated that set minimum efficiency levels for manufacturers of space-conditioning and water-heating equipment. With passage of the 1992 Energy Policy Act, a stronger, consistent reference point was established for all states against which to adopt, modify, and/or compare their energy codes.

The DOE is required by law (the Energy Conservation and Production Act, as amended [ECPA]) to issue a determination as to whether the latest edition of ASHRAE/IESNA Standard 90.1 (for commercial buildings and multifamily high-rise residential buildings) will improve energy efficiency compared to the previous edition of the corresponding code or standard. The DOE has one year to publish a determination in the *Federal Register* after each new edition of the code or standard is published, and states have two years from the determination date to respond to the DOE regarding the equivalency of their own energy codes.

The IECC is developed under the auspices of the International Code Council (ICC) using a government consensus process. This process allows all interested parties to participate, but the final vote on the content of the codes is made by individuals associated with federal, state, or local governments who are also members of the ICC. The IECC is one of 15 model codes developed under the auspices of the ICC that, combined, provide the foundation for a complete set of building regulations covering all aspects of construction, including plumbing, electrical, fire protection, fuel gas, energy, and mechanical. The ICC codes are updated every three years, providing a model that states and local jurisdictions can adopt as is or modify as necessary to reflect regional building practices or state-specific energy efficiency goals.

California uses the ICC codes as the primary foundation for establishing the requirements of the *California Building Code*, except for energy efficiency, which are promulgated by the California Energy Commission's regulations encompassed in the *Building Energy Efficiency Standards*.

CHAPTER 2: Energy Comparison Analysis

The low-rise residential energy codes of California and those of the national model energy codes are virtually identical in scope—each code establishes minimum energy efficiency levels for the building envelope, space heating, space cooling, water heating, and lighting. They differ considerably in the efficiency levels of building components, operating conditions, space and water heating system effects, and lighting allowances and control measures, all of which can lead to differences in the overall stringency between the two sets of energy codes.

The required maximum energy threshold for building energy use depends on three key variables: 1) the climate zone where construction is to occur, (2) baseline building efficiency measures encompassed by the energy code or standard, and (3) building-dependent operating and modeling assumptions used for compliance. The interaction of these variables can result in different estimated energy uses for a given building regardless of mandatory measure requirements or demonstrated compliance using either the prescriptive or performance method.

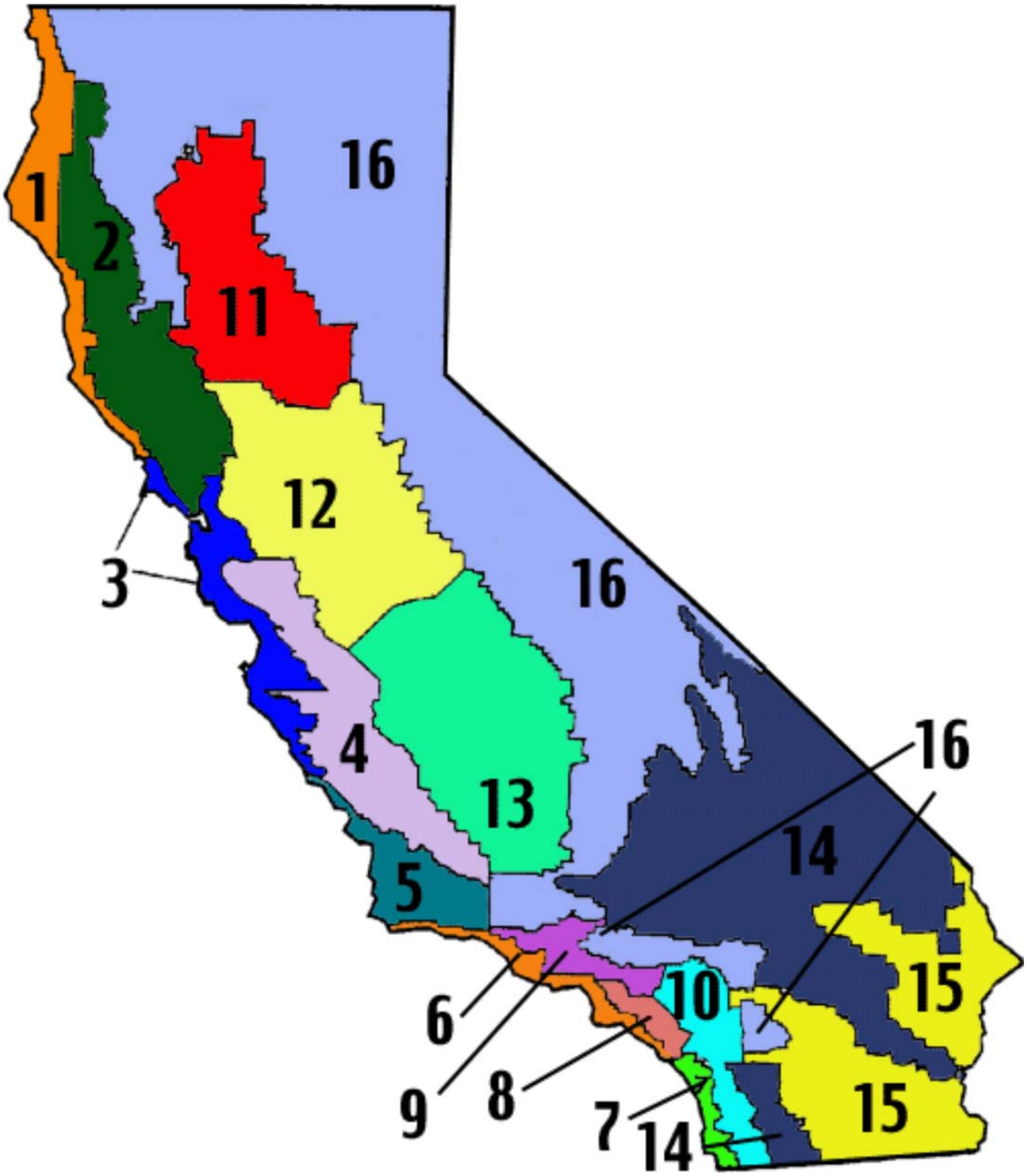
Climate Variables

For building energy efficiency purposes, California's *Building Energy Efficiency Standards* divide the state into 16 climate zones. In contrast, the national model energy codes have established eight climate regions for the nation and subcategorize areas in each region as either moist, dry, or marine with the letter code of "a," "b," or "c," respectively. Figure 1 shows the 16 climate zones use for the state's *Building Energy Efficiency Standards*. Figure 2 displays the climate zones of the *IECC* and *ASHRAE/IESNA Standard 90.1* as they would apply to California. Table 1 shows a breakdown of the national climate zones within the 16 climate designations of California's *Building Energy Efficiency Standards* and each associated national climate zone.

Five of the eight *ASHRAE/IESNA Standard 90.1* national climates zones (Climate Zones 2-6) are represented in California, though the majority of the state is represented by *IECC* and *ASHRAE/IESNA Standard 90.1* Climate Zone 3.

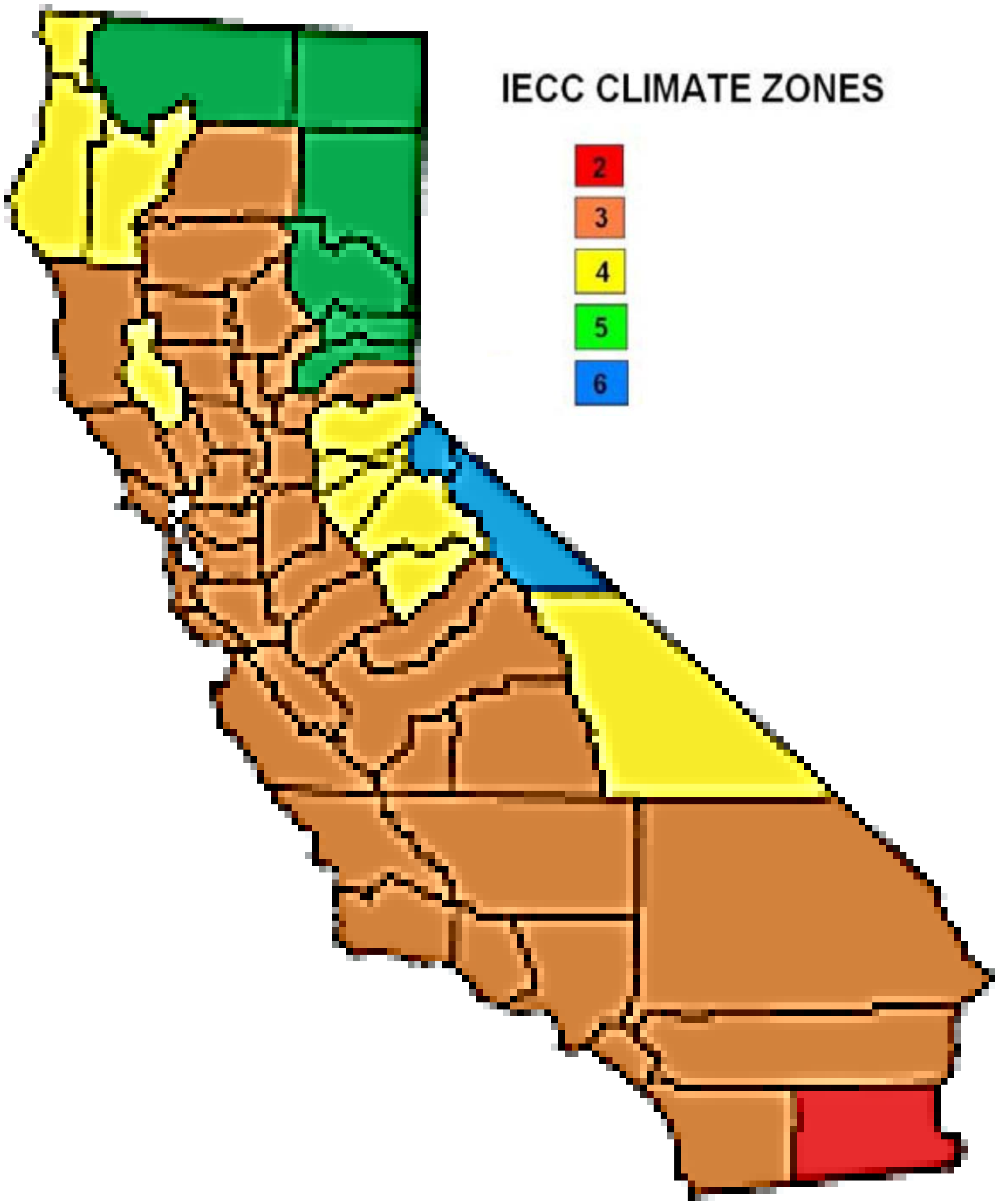
The national climate regions are drawn based on county lines, whereas California's 16 climate zones are drawn based on the results of climate data analysis, where some climate lines may coincide with boundaries of cities or counties. Hence, when showing compliance with California's *Building Energy Efficiency Standards,* a California city or county could have several climate designations within the same jurisdiction, whereas, this does not occur with climate zones of the *IECC* and *ASHRAE/IESNA Standard 90.1*. The weather station whose data were used for each of the 18 climate zone pairs is given in the third column of Table 1.

Figure 1: California Climate Zones—Building Energy Efficiency Standards



Source: California Energy Commission staff

Figure 2: California Climate Zones—IECC and ASHRAE/IESNA Standard 90.1



Source: California Energy Commission staff

Table 1: Comparison of Climate Designations

CA Climate Zone	DoE Climate Zone	Weather Station
1	4c	ARCATA
2	3c	SANTA ROSA
3	3c	OAKLAND
4	3c	SAN JOSE
5	3c	SANTA MARIA
6	3c	TORRANCE
7	3b	SANDIEGO
8	3b	FULLERTON
9	3b	BURBANK
10	3b	RIVERSIDE
11	3b	RED BLUFF
12	3b	SACRAMENTO
13	3b	FRESNO
14	4b	PALMDALE
15	2b	PALM SPRINGS
16	4b	SOUTH LAKE TAHOE
16	5b	SOUTH LAKE TAHOE
16	6b	SOUTH LAKE TAHOE

Source: California Energy Commission staff

Energy use estimates of building energy features are affected by climate. For comparative analysis of the two sets of energy codes, energy use estimates were based on climate designations for California's standards, and building measures were altered based on the requirements specific to the respective national energy code. Separate modeling analysis was conducted for each *IECC* climate condition for California, illustrated by Table 1.

Building Energy Efficiency Measures

For low-rise residential buildings, the estimated energy use for building measures described in the prescriptive requirements of Section 150.1 of the *2016 Building Energy Efficiency Standards* were compared against similar requirements of the *IECC-2015*.

Low-rise residential performance modeling analysis used several prototype buildings, which were provided by the software as example projects. Energy Commission staff performed this energy analysis using 2016 version of California Building Energy Code Compliance (CBECC) software for residential buildings (CBECC-Res).[2]

2 http://www.bwilcox.com/BEES/BEES.html.

For comparative energy analysis of the low-rise residential buildings, the applicable prescriptive requirements of the *2016 Building Energy Efficiency Standards* were used to establish the energy baseline of the standard design building used within the modeling program. Features of the proposed design building were altered, depending on the building prototype, to match building measures required by *IECC-2015*.

Operating Conditions and Modeling Assumptions

Differences in assumed building operating conditions, schedules, and modeling assumptions used for building features can significantly affect a comparative analysis of the stringency of the two sets of energy codes. For this reason, building operating conditions for the analysis were assumed to be from California's standards.

CHAPTER 3: Energy Comparison Results

California's metric for building energy use is time-dependent valuation (TDV). TDV is the net present value of the time-varying energy used by the building to provide space conditioning, water heating, and specified lighting of buildings. This metric is an alternative to source energy, which is the energy used at a site and consumed in producing and delivering energy to a site, including but not limited to, power generation, transmission, and distribution losses, and that is used to perform a specific function, such as space conditioning, lighting, or water heating. TDV is used by Energy Commission-approved performance compliance modeling software to depict estimated building energy use.

Unlike source energy, TDV accounts for the time when energy is used. Therefore, building features that save more energy during high electricity peak usage periods are weighted more heavily than during nonpeak periods. For electricity, TDV is high during hot summer afternoons and low under colder temperatures, typically at night. TDV is intended to represent real-time electricity prices. Buildings optimized under TDV tend to be less expensive to operate since more energy would be saved during periods when prices are high.

Residential Energy Use Estimates

Table 2 displays modeling results that compare the estimated annual energy savings between the *2016 Building Energy Efficiency Standards* and *IECC – 2015*. Annual estimates of energy use have been weighted by construction starts for each climate zone.

Data were obtained from CBECC-Res, for each of the three types of low-rise residential buildings in TDV energy use intensity (EUI), providing the thousands of British thermal units (kBtu) consumed per square foot for each of the 16 California climate zones, as well as the seven *IECC/ASHRAE* climate subzones. Eighteen comparisons could then be made among the corresponding zones, according to Table 1. The result of this comparison was a balance sheet with 18 lines for each of the three buildings where the value was positive, indicating the amount saved by *2016 Building Energy Efficiency Standards* over *IECC-2015*. These data are in billions of British thermal units (GBtu) consumed per square foot and so are normed for the actual number of such buildings in each climate zone projected to start in 2017 when the 2016 Standards came into effect.

Table 2: Statewide Annual Energy Use - *2016 Building Energy Efficiency Standards* and IECC-2015

TOTAL Annual TDV EUI GBtu Savings of Title 24 Over IECC					
Weather Station	**CA Climate Zone**	**DOE Climate Zone**	**Single-Family One Story**	**Single-Family Two Story**	**Multi-Family**
ARCATA	1	4c	4.94	6.98	3.33
SANTA ROSA	2	3c	25.57	32.07	49.43
OAKLAND	3	3c	83.07	107.84	271.99
SAN JOSE	4	3c	54.30	80.35	130.34
SANTA MARIA	5	3c	23.69	28.50	16.74
TORRANCE	6	3c	22.12	29.83	160.78
SAN DIEGO	7	3b	39.91	47.40	190.53
FULLERTON	8	3b	52.88	76.76	433.57
BURBANK	9	3b	83.59	132.34	1199.56
RIVERSIDE	10	3b	187.21	274.20	295.68
RED BLUFF	11	3b	105.22	155.23	43.88
SACRAMENTO	12	3b	244.65	379.24	253.63
FRESNO	13	3b	249.26	363.19	160.16
PALMDALE	14	4b	53.06	95.62	112.74
PALM SPRINGS	15	2b	121.56	217.04	138.84
SOUTH LAKE TAHOE	16	4b	10.08	24.69	57.65
SOUTH LAKE TAHOE	16	5b	6.68	14.61	22.06
SOUTH LAKE TAHOE	16	6b	0.41	1.18	2.43
total by building type			**1368.18**	**2067.06**	**3543.33**

Source: California Energy Commission staff [3]

The projected building starts were obtained from the 2016 impact analysis conducted by the Energy Commission. The original data used in the analysis were generated by the Energy Commission's Energy Assessment Division by starting with permit data purchased from Dodge Data and Analytics (formerly McGraw Hill Construction). These raw data were converted to projected building completions using an in-house algorithm that takes into account building types and locations. These completion data were then projected forward 10 years using the mean life of each building type and benchmarking the data from historical commercial end-use surveys. A logistic decay function then honed in to a better approximation by creating a complete historical data series for floor space. This historical floor space series was finally projected forward again using a linear mixed model to include economic and demographic variables such as employment, personal income, and population in each region.

The projected building starts data used for 2017 are in number of units for each of the three building types surveyed, and some assumptions are made when splitting up some of those columns into the building types modeled in this analysis. Based on occupancy data discussed in the 2016 impact report, 45 percent of single family homes are weighted as the 2,100 ft^2 single-story prototype and the remaining 55 percent classified as the 2,700 ft^2 two-story prototype. Low-rise multifamily is modeled as a 6,960 ft^2 two-story prototype with eight dwellings. Lastly, projected building start data were available only for Climate Zone 16 as a whole and not for the three *ASHRAE* subzones it includes. California Climate Zone 16 projected start data were therefore divided into the three *IECC* subzones based on population projections from the U.S. Census Bureau for each of the subzones: the large 5b northern inland mountain region was projected to have a population of 122,954, while the smaller but denser 4b zone was projected to have a population of 355,781, and the 6b zone was projected to have a population of 15,019. Ultimately, the chart of projected building starts with 18 lines for each of the three buildings in millions of square feet was obtained.

The balance sheet from the modeling in GBtu per square foot was then merged with the projected building starts in millions of square feet, to yield an 18 by 3 balance sheet of GBTU saved by using Title 24 vs. *IECC-2015* as shown in Table 2. In sum, the energy savings of Title 24 over IECC can be estimated to be at least 6,979 GBtu annually.

A similar analysis as described above was performed for the percentage of annual TDV energy saved by Title 24 over *IECC-2015*. The total projected annual TDV EUI in GBtu for buildings complying with Title 24 was subtracted from those complying with *IECC-2015* and this value divided by that for those complying with *IECC-2015* to obtain a total annual Title 24 percent better than *IECC*-2015 value for each climate zone and occupancy. These values are displayed in Table 3.

Table 3: Title 24 Percentage Better Than IECC Table

TOTAL Annual Title 24 Percent Better Than IECC					
Weather Station	**CA Climate Zone**	**DOE Climate Zone**	**Single-Family One Story**	**Single-Family Two Story**	**Multi-Family**
ARCATA	1	4c	14.12	16.29	28.15
SANTA ROSA	2	3c	23.00	22.12	34.26
OAKLAND	3	3c	39.94	41.27	37.92
SAN JOSE	4	3c	25.02	26.73	41.85
SANTA MARIA	5	3c	48.36	48.08	39.40
TORRANCE	6	3c	22.22	21.84	35.68
SAN DIEGO	7	3b	33.98	31.03	37.22
FULLERTON	8	3b	28.64	28.64	38.93
BURBANK	9	3b	24.74	26.67	39.79
RIVERSIDE	10	3b	26.45	26.81	41.03
RED BLUFF	11	3b	22.36	23.23	36.26
SACRAMENTO	12	3b	24.13	25.67	38.14
FRESNO	13	3b	22.34	22.95	36.59
PALMDALE	14	4b	21.31	25.63	40.49
PALM SPRINGS	15	2b	25.57	31.05	38.43
SOUTH LAKE TAHOE	16	4b	7.43	12.57	35.33
SOUTH LAKE TAHOE	16	5b	13.33	19.75	37.69
SOUTH LAKE TAHOE	16	6b	7.10	13.96	35.29
average by building type			**23.89**	**25.79**	**37.36**

Source: California Energy Commission staff [3]

3 In addition, there are two areas of building energy efficiency savings in Title 24 that could not be directly captured by performance modeling analysis of the IECC prototype buildings; these are lighting power use and water heating. IECC allows for 25 percent of residential lighting to come for non-high-efficacy sources, whereas Title 24 requires 100 percent high-efficacy sources. This could result in a net additional energy savings of up to 995 GBtu annually. Similarly IECC allows for the use of electric resistance water heating. Evaluating the impact of electric resistance water heating versus instantaneous gas water heating, as used for the Title 24 baseline, results in an additional 50 GBtu that could be saved annually for 6 percent of residential occupancies that use electricity as a fuel source.

CHAPTER 4: Conclusion

The analysis shows that *California's 2016 Building Energy Efficiency Standards* exceed the energy savings expected from requirements of *IECC-2015*. While improvements in the energy stringency levels of the national reference energy codes continue, California's low-rise residential energy standards contain building measures and building performance operation impacts that are more rigorous, resulting in higher efficiency levels for new low-rise residential construction than expected to occur from efficiency requirements of the federal reference energy codes. Table 4 displays the total annual TDV EUI saved in GBtu by complying with Title 24 vs. *IECC-2015*, while Table 5 displays the total annual Title 24 percent better than *IECC-2015* values per climate zone. The total amount of energy saved annually by complying with California's Title 24 Standards is 6,979 GBtu, which is on average 29 percent better than complying with *IECC-2015*.

Table 4: Savings Summary Table

TOTAL Annual TDV EUI GBtu Savings			
Weather Station	**CA Climate Zone**	**DOE Climate Zone**	**total by Climate Zone**
ARCATA	1	4c	**15.24**
SANTA ROSA	2	3c	**107.08**
OAKLAND	3	3c	**462.90**
SAN JOSE	4	3c	**264.99**
SANTA MARIA	5	3c	**68.93**
TORRANCE	6	3c	**212.72**
SAN DIEGO	7	3b	**277.83**
FULLERTON	8	3b	**563.20**
BURBANK	9	3b	**1415.49**
RIVERSIDE	10	3b	**757.10**
RED BLUFF	11	3b	**304.33**
SACRAMENTO	12	3b	**877.52**
FRESNO	13	3b	**772.61**
PALMDALE	14	4b	**261.41**
PALM SPRINGS	15	2b	**477.44**
SOUTH LAKE TAHOE	16	4b	**92.41**
SOUTH LAKE TAHOE	16	5b	**43.34**
SOUTH LAKE TAHOE	16	6b	**4.01**
TOTAL ANNUAL CALIFORNIA SAVINGS			***6979***

Source: California Energy Commission staff [4]

Table 5: Percentage Better Summary Table

AVERAGE Annual Percent Better			
Weather Station	**CA Climate Zone**	**DOE Climate Zone**	**AVERAGE by Climate Zone**
ARCATA	1	4c	19.52
SANTA ROSA	2	3c	26.46
OAKLAND	3	3c	39.71
SAN JOSE	4	3c	31.20
SANTA MARIA	5	3c	45.28
TORRANCE	6	3c	26.58
SAN DIEGO	7	3b	34.08
FULLERTON	8	3b	32.07
BURBANK	9	3b	30.40
RIVERSIDE	10	3b	31.43
RED BLUFF	11	3b	27.28
SACRAMENTO	12	3b	29.31
FRESNO	13	3b	27.30
PALMDALE	14	4b	29.15
PALM SPRINGS	15	2b	31.68
SOUTH LAKE TAHOE	16	4b	18.44
SOUTH LAKE TAHOE	16	5b	23.59
SOUTH LAKE TAHOE	16	6b	18.79
AVERAGE Annual California Percent Better			***29***

Source: California Energy Commission staff [4]

4 Including additional savings from enhanced lighting power use and water heating baselines could bring the total annual energy saved by using Title 24 vs. IECC Standards to 8,024 GBtu annually or 30 percent better.